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(54) MICROMACHINED SENSOR DEVICE

MIKROTECHNOLOGISCH HERGESTELLTER SENSOR

CAPTEUR MICRO-USINE

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- **SENSORS AND ACTUATORS A vol. A31, no. 1/3, March 1992, LAUSANNE CH pages 215 - 219 , XP000276429 B.S. DOUMA ET AL. 'MODELLING THE PRESSURE AND TEMPERATURE SENSITIVITY OF AN OPTICALLY EXCITED MICROMACHINED SILICON SENSOR FOR PERMANENTLY INSTALLED DOWNHOLE MONITORING SYSTEMS'**
- **SENSORS AND ACTUATORS A vol. A31, no. 1/3, March 1992, LAUSANNE CH pages 164 - 167, XP000276421 T. KVISTEROY ET AL. 'OPTICALLY EXCITED SILICON SENSOR FOR PERMANENTLY INSTALLED DOWNHOLE PRESSURE MONITORING APPLICATIONS'**

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EP 0 634 008 B1

Description

The present invention relates to a method for monitoring strain variations of a strain responsive element of a micromachined silicon sensor device, being a butterfly sensor, according to the first part of claim 1 (GB-A-2189600) for the determination of parameters affecting the butterfly sensor. Furthermore it rotates to a corresponding system according to the first part of claim 12.

GB 2 223 582 addresses a pressure responsive device, for example to be used as a "down well" sensor in oil drilling and exploration. Only pressure response is known for this device. In particular said sensors are made from single crystal silicon. Pressure and temperature response are known from EP-A2,3-136 627 operating with two vibration modes.

In the article by Andres et al., "Sensitivity and mode spectrum of a frequency-output silicon pressure sensor", Sensors and Actuators, 15 (1988), pages 417-426, different vibrational modes of a so-called butterfly silicon sensor integral with a thin diaphragm are shown. The modes are investigated by activating electrically and interrogating optically. In particular for said modes relationships between resonance frequency and pressure are determined. The modes M_{nm} are classified in accordance with position and direction of node-axes.

In the article by Uttamchandani et al., "Optically excited resonant beam pressure sensor", Electronic Letters, 3rd December 1987, Vol. 23, No. 25, pages 1333-1334, resonance frequency/pressure and resonance frequency/temperature relationships for the fundamental mode of vibration of a beam-type micromachined silicon resonator are determined. No further interrelationships or dependencies are shown.

Moreover from the above documents the usual way of driving such resonators and detecting resonance frequencies by optical activation/interrogation techniques is known. In particular two light sources, i.e. a pulsed mode source for activation and a continuous-wave source for interrogation are employed. Light transmitted by said sources is joined and guided in one fibre to the sensor, thus avoiding complex instrumental arrangements at the measuring position.

Whereas from the above advantageous use of one single fibre for activation and interrogation of the vibrational modes of such sensors is known only determination of corresponding one parameter responsible for operation conditions as mentioned is realised.

However, in most cases it is necessary to determine a set of parameters to qualify accurately working conditions in hostile environmental situations. For example in the above mentioned downhole circumstances exploration and production activities should be carried out at operation conditions as safe as possible. Especially pressure/temperature combinations should be monitored closely and reliably. Moreover, with respect to production activities, permanently installed sensor devices have to be used for long time periods.

To remedy the shortcomings as addressed above several solutions are proposed. For example in the article by Vincent et al., "An All-optical Single-fibre Micromachined Silicon Resonant Sensor: Towards a Commercial Device", Sensors and Actuators A, 25-27 (1991), pages 209-212, both the use of a set of sensors, called multiplexing sensors, with different resonance frequencies, and mechanical temperature compensation are disclosed.

A further compensation method is known from EP 371 592. Also one fibre communication linkage is applied. The sensor device shown comprises a couple of two strain responsive silicon beams, the one being affected by both pressure and temperature variations, the other having a free end only being subjected to temperature variations. Thus temperature corrections can be made.

However, the solutions and options as presented in the documents discussed, either seem to represent only a device development stage, or employ multicomponent sensor devices and related complex or incomplete parameter monitoring programmes.

Thus it is a main object of the present invention to present a method capable of determining a set of outside parameters by means of a single micromachined sensor device in a reliable and accurate way.

It is a further object of the invention to determine said outside parameters in only one frequency sweep.

Therefore the present invention provides a method of claim 1.

Furthermore in accordance with the invention a system of claim 12 is presented.

The present invention will now be described by way of example in more detail with reference to the accompanying drawing, wherein

Figure 1 shows an enlarged top view of a cross-section of a measuring tube including a micromachined sensor device for carrying out the method of the present invention, and

Figure 2 shows an enlarged top view of a cross-section of a butterfly sensor.

In both figures the same sensor components are referred to the same reference members.

Referring to Figure 1 a micromachined sensor means 1 is mounted within a tubular housing 2 shown in a cross-sectional view. Said housing is subjected to outside parameter variations and conditions to be monitored and sensed by said sensor device.

Sensor device 1, of which a top view is shown, has the form of a thin plate and is mounted within and connected to the housing 2 by means of frits 9 of which by way of example two ones, black coloured, are shown.

More in detail sensor means 1 comprises a so-called butterfly sensor 3. Said sensor 3 generally comprises two rectangular paddles 4 arranged in line and at their mutually facing short sides connected to each other

by means of a hinge 5. Each paddle 4 is at its two long sides coupled to a support means 7 by means of at least corresponding two string means 6. Paddles 4, hinge 5 and string means 6 extend in the same plane and form the strain responsive element.

As can be seen in said figure said string means exist of a V-formed pair of strings, having V-bottoms arranged on the above said long sides, and the V-ends arranged on said support means 7.

Typically said sensor or sensor devices have sizes up to 1000 μm. They are made from amorphous silicon, polycrystalline silicon, single crystal silicon, or even from suitable metals. Recesses, holes, and further relief features are obtained for example by etching or deposition techniques which are well known to those skilled in the art. Tubes and sensor means are made from the same material. Usually said sensors are addressed as micromachined silicon sensors.

While only a so-called butterfly sensor device is shown, a plurality of further sensor embodiments is known from the literature as discussed above. Especially beam type sensor devices are investigated widely.

As can be seen in said figure the butterfly sensor 3 is coupled to support means 7 which in turn is connected to a leverage construction 8 connected with the above said frits 9 to the housing and enabling advantageous activation of the butterfly. In this arrangement strain affecting variations are transferred through the tubular housing to the leverage which in turn influences strain geometry in the string means.

Besides the above leverage construction, support means 7 can also form a well known console-means which are arranged upon and connected to, i.e. mostly integrally formed with, an end wall of said tubular housing. In that case said end wall functions as a diaphragm for transferring said outside parameter conditions.

As will be clear to those skilled in the art the sensor devices as mentioned above borrow their action on creating strain variations in their strain responsive element which is effected by means of the string means shown. Thus, in principle any strain related parameter can be sensed by such a sensor device. Evident examples of such parameters are pressure and temperature. Further examples may be flow, vibration, displacement which is kinematically related to flow and vibration, and pressure fluctuations caused by passing chemical interfaces or fluctuating chemical conditions. In a further embodiment of the present invention it is possible to evacuate the tubular housing to optimise vibration of the strain responsive elements.

In order to operate such a sensor device it is well known to use both electrical and optical activation and interrogation. Especially the optical method is preferred because the use of one light beam covers both activation and interrogation and reduces circuitry complexity of such detector and sensor systems substantially. Preferably optical fibres are used for guiding light signals and creating a relatively narrow beam irradiating the sensor device.

For the sensor device in accordance with the present invention in principal all kinds of fibres can be used i.e. single mode, multimode, graded index, step index, related to corresponding fibre diameters, for example from 4 μm to 1000 μm.

As known from the literature such sensor devices have a set of vibrational modes. Since the geometry and mechanics of said modes have to be distinguished clearly as to number and position of for example their node-axes, they can be referred to as M_{nm}, as shown in the above cited article by Andres et al. However different mode characterisations can be used and are per se strictly related to the above M_{nm}. In the present invention in particular M_{02} and M_{04}, also referred to as the third and sixth mode, are activated.

As is well known to those skilled in the art optical activation and interrogation can be carried out in different ways. Principally irradiating the sensor by means of a beam of light induces temperature gradients causing strain variations. In the case of irradiating by means of a non-continuous wave beam having a non-continuous intensity, said strain variations cause oscillations. Dependent on the frequency of said light intensity variations, resonance frequencies can be excited, and dependent on the resulting oscillation of the sensor, light is reflected correspondingly. Thus from the reflected beam as modified by said oscillations, resonance frequency modes are detected, and consequently said resonance frequencies are measured.

For said activation well known intensity variations like block pulse, sinusoidal, or saw-tooth variations are used.

For the M_{02} and M_{04} resonance modes, resonance frequencies respectively around 60 and 170 kHz are employed. In order to cover a set of modes in one activation run the frequency for the variations or modulations of the intensity of the irradiating beam of light is swept for example from 10 to 500 kHz, preferably from 50 to 200 kHz.

Further to the above activation light signal, it is well known to employ a continuous-wave signal component, thereby improving detection of reflected beams. Generally intensity variations, in particular interference variations, are detected. Especially the latter case is accomplished as a fibre, which guides the above signals, is used, and the space between fibre end and sensor surface is employed as a well known resonance cavity. Generally the irradiating beam forms a spot upon the sensor device. By matching fibre characteristics, like diameter and direction, with sensor characteristics, like mass and width, modified intensity variations as induced by the sensor device are detected optimally.

Prior to operating it is necessary to set, to calibrate, and to characterize some sensor features in order to use the sensor as a reliable measuring and detecting device. For example location of the spot on the sensor device, direction of the beam of light irradiating the sensor, angle

between beam or fibre axis and normal of the sensor plane, and distance between fibre end and sensor plane have to be set accurately. Especially as to outside parameter conditions it has appeared possible to characterise relationships between said parameters and said resonance frequencies. Dependent on particular strain properties, sets of parameters are matched on said properties. In the case of detecting both pressure and temperature dependencies, at least two twofold frequency/pressure-temperature relationships have to be determined.

In accordance with the present invention it has appeared advantageous to determine pressure and temperature characteristics for the above-mentioned M_{02} and M_{04} resonance modes. Said characteristics include for each resonance frequency an equation comprising specific temperature and pressure dependencies. Combining the two corresponding characteristics enables deriving pressure and temperature values. Thus by applying the above discussed method in accordance with the present invention pressure and temperature values, respectively between 0 and 2000 bar, and 0 and 350 °C, preferably between 35 and 1000 bar, and 20 and 200 °C, are determined.

A system for carrying out the procedures in accordance with the method of the present invention includes a light beam supply means for irradiating the strain responsive element of the micromachined sensor, a frequency oscillator means for generating a beam with frequency swept modulated intensity in order to activate said element in at least two oscillation resonance modes at their resonance frequencies, detecting means for detecting the beam of light modified by said activated element, meaning means for measuring the resonance frequencies from said modified beam, and processing means for processing resonance frequency values and deriving therefrom at least correspondingly two outside parameter values.

Advantageously the system comprises a continuous wave generating means for generating an additional continuous-wave signal component.

EXAMPLE

In an example as given below further details as to the method and system of the invention when using a butterfly sensor are shown.

Referring to figure 2 a butterfly sensor 3 comprises the above shown paddles 4, hinge 5, string means 6, and support means 7. In more detail the butterfly sensor comprises holes 10 alongside hinge 5 in order to make the paddles 4 more flexible. Usually said holes 10 are rectangular.

In the experiments carried out with the sensor as shown in figure 2 the following operation conditions were used:

- pulsed mode laser diode, wave length 1550 nm,
- continuous-wave mode laser diode, wave length 1300 nm,
- spot location alongside one of the holes,
- fibre axis/normal - angle, 1°,
- fibre end/paddle surface - distance, 100 μm.

With respect to the above it is noted that at least 60% of the beam light energy should arrive on the paddle, more advantageously at least 80%.

Furthermore, it has appeared that said fibre axis/-normal - angle should be less than 5°, preferably less than 2°, and distances between fibre end and paddle surface should lie in the range from 20 to 200 μm, preferably from 50 to 150 μm, to give advantageous parameter values.

In the above conditions, resulting in resonance frequencies of 62 kHz and 173 kHz for respectively the M_{02}- and the M_{04}-mode, temperature and pressure values, respectively between 20 and 100 °C and up to 200 bar are determined. Errors in said values did not exceed 0.1 °C and 0.1 bar.

By applying the above method and system it has appeared possible to monitor conditions in hostile environments reliably and accurately which is of great interest, especially with regard to safety requirements.

Claims

1. A method for monitoring strain variations of a strain responsive element of a micromachined silicon sensor device, being a butterfly sensor (3), which comprises at least two rectangular paddles (4) arranged in line and at their mutually facing short sides connected to each other by means of a hinge (5), each paddle (4) at its two long sides coupled to a support means (7) by means of at least corresponding two string means (6), paddles, hinge (5) and string means (6) extending in the same plane and forming the strain responsive element, the method comprising the steps of:

   - irradiating said element (3) by a beam of light with modulated intensity for activating said element (3) in order to oscillate in a corresponding torsional oscillation resonance mode M_{nm} at its resonance frequency,
   - determining frequency characteristics of said device (3) when subjected to predefined parameter conditions,
   - subjecting said element (3) to outside parameter conditions, and
   - detecting the beam of light after being modified correspondingly by said activated element (3),

   characterized in that said beam of light forms a beam of light with at least frequency swept modulated intensity, and that the method further compris-

es:

- activating subsequently at least two oscillation resonance modes,
- measuring the corresponding two resonance frequencies, and
- determining correspondingly two parameter values by fitting the resonance frequencies upon the corresponding frequency characteristics.

2. The method as claimed in claim 1, wherein the M_{02} and M_{04} oscillation resonance modes are activated.

3. The method as claimed in claim 1, wherein said string means (6) exist of a V-formed pair of strings, the V-bottoms arranged on said sides, and the V-ends arranged on said support means (7).

4. The method as claimed in any one of the foregoing claims, wherein the device is arranged within a substantially evacuated tubular housing (2) which is subjected to said outside parameter conditions transferred to said device (3) through said support means (7).

5. The method as claimed in claim 4, wherein said support means (7) form a console-means, arranged upon and connected to an end wall of said housing (2), the end wall operating as a diaphragm for said outside parameter conditions.

6. The method as claimed in claim 4, wherein said support means (7) are a part of a leverage construction (8), said construction (8) being connected to the cylindrical wall of said housing (2) for transferring said outside parameter conditions.

7. The method as claimed in claim 1, wherein the frequency is swept between 10 and 500 kHz, preferably between 50 and 200 kHz.

8. The method as claimed in any one of the claims 1 to 7, wherein the beam of light irradiating the butterfly sensor is focused to a spot upon one of said paddles (4), the major part of the spot being localised alongside the hinge (5).

9. The method as claimed in any one of the foregoing claims, wherein the beam of light irradiating said element (3) further comprises a continuous-wave signal component.

10. The method as claimed in any one of the foregoing claims, wherein both pressure and temperature values are determined.

11. The method as claimed in any one of the foregoing claims wherein pressure and temperature values are measured, respectively between 0 and 2000 bar and 0 and 350 °C, preferably between 35 and 1000 bar and 20 and 200 °C.

12. A system for monitoring strain variations of a strain responsive element of a micromachined silicon sensor device, being a butterfly sensor (3), which comprises at least two rectangular paddles (4) arranged in line and at their mutually facing short sides connected to each other by means of a hinge (5), each paddle (4) at its two long sides coupled to a support means (7) by means of at least corresponding two string means (6), paddles, hinge (5) and string means (6) extending in the same plane and forming the strain responsive element, the system comprising:

- means for irradiating said element (3) by a beam of light with modulated intensity for activating said element (3) in order to oscillate in a corresponding torsional oscillation resonance mode M_{nm} at its resonance frequency,
- means for determining frequency characteristics of said device (3) when subjected to predefined parameter conditions,
- means for subjecting said element (3) to outside parameter conditions, and
- means for detecting the beam of light after being modified correspondingly by said activated element (3),

characterized in that the beam of light forms a beam of light with at least frequency swept modulated intensity, and that the system further comprises:

- means for activating subsequently at least two oscillation resonance modes,
- means for measuring the corresponding two resonance frequencies, and
- means for determining correspondingly two parameter values by fitting the resonance frequencies upon the corresponding frequency characteristics.

Patentansprüche

1. Verfahren zum Überwachen von Dehnungsschwankungen eines dehnungsempfindlichen Elements einer mikrobearbeiteten Sensoreinrichtung aus Silicium, wobei es sich um einen Schmetterlingssensor (3) handelt, mit mindestens zwei rechteckigen Paddeln (4), die in einer Linie angeordnet sind und an ihren einander gegenüberliegenden kurzen Seiten miteinander durch ein Gelenk (5) verbunden sind, wobei jedes Paddel (4) an seinen beiden Längsseiten durch mindestens entsprechende

zwei Fadenmittel (6) an ein Trägermittel (7) angekoppelt ist, wobei die Paddel, das Gelenk (5) und die Fadenmittel (6) in der gleichen Ebene verlaufen und das dehnungsempfindliche Element bilden, wobei das Verfahren folgende Schritte umfaßt:

- Beleuchten des Elements (3) mit einem Lichtstrahl mit modulierter Intensität zum Aktivieren des Elements (3), damit es bei seiner Resonanzfrequenz in einer entsprechenden Drehoszillations-Resonanzmode M_{nm} oszilliert,
- Bestimmen der Frequenzkennlinie der Einrichtung (3), wenn sie vorbestimmten Parameterbedingungen ausgesetzt ist,
- das Element (3) den äußeren Parameterbedingungen aussetzen und
- Erfassen des Lichtstrahls nach entsprechender Modifizierung durch das aktivierte Element (3),

dadurch gekennzeichnet, daß der Lichtstrahl einen Lichtstrahl mit mindestens frequenzmäßig durchlaufener modulierter Intensität bildet und daß das Verfahren weiterhin folgendes umfaßt:

- nachfolgende Aktivierung bei mindestens zwei Oszillations-Resonanzmoden,
- Messen der entsprechenden zwei Resonanzfrequenzen und
- entsprechendes Bestimmen zweier Parameterwerte durch Anpassen der Resonanzfrequenzen an die entsprechende Frequenzkennlinie.

2. Verfahren nach Anspruch 1, bei dem die M_{02}- und M_{04}-Oszillations-Resonanzmoden aktiviert werden.

3. Verfahren nach Anspruch 1, bei dem die Fadenmittel (6) als ein V-geformtes Paar von Fäden vorliegen, wobei die V-Unterseiten an den Seiten angeordnet sind und die V-Enden an dem Trägermitteln (7) angeordnet sind.

4. Verfahren nach einem der vorhergehenden Ansprüche, bei dem die Einrichtung in einem im wesentlichen evakuierten rohrförmigen Gehäuse (2) angeordnet ist, das den äußeren Parameterbedingungen ausgesetzt ist, die durch das Trägermittel (7) auf die Einrichtung (3) übertragen werden.

5. Verfahren nach Anspruch 4, bei dem die Trägermittel (7) ein Konsolenmittel bilden, das an einer Endwand des Gehäuses (2) angeordnet und damit verbunden ist, wobei die Endwand für die äußeren Parameterbedingungen wie eine Membran wirkt.

6. Verfahren nach Anspruch 4, bei dem die Trägermittel (7) Teil einer Hebelstruktur (8) sind, wobei die Struktur (8) zum Übertragen der äußeren Parameterbedingungen mit der zylindrischen Wand des Gehäuses (2) verbunden ist.

7. Verfahren nach Anspruch 1, bei dem die Frequenz zwischen 10 und 500 kHz, vorzugsweise zwischen 50 und 200 kHz, durchlaufen wird.

8. Verfahren nach einem der Ansprüche 1 bis 7, bei dem der den Schmetterlingssensor beleuchtende Lichtstrahl auf einen Fleck auf einem der Paddel (4) fokussiert wird, wobei der Hauptteil des Flecks entlang des Gelenks (5) liegt.

9. Verfahren nach einem der vorhergehenden Ansprüche, bei dem der das Element (3) beleuchtende Lichtstrahl weiterhin eine Dauerstrich-Signalkomponente umfaßt.

10. Verfahren nach einem der vorhergehenden Ansprüche, bei dem sowohl Druck- als auch Temperaturwerte bestimmt werden.

11. Verfahren nach einem der vorhergehenden Ansprüche, bei dem Druck- und Temperaturwerte zwischen 0 und 2000 bar bzw. 0 und 350°C, vorzugsweise zwischen 35 und 1000 bar bzw. 20 und 200°C, gemessen werden.

12. System zum Überwachen von Dehnungsschwankungen eines dehnungsempfindlichen Elements einer mikrobearbeiteten Sensoreinrichtung aus Silicium, wobei es sich um einen Schmetterlingssensor (3) handelt, mit mindestens zwei rechteckigen Paddeln (4), die in einer Linie angeordnet sind und an ihren einander gegenüberliegenden kurzen Seiten miteinander durch ein Gelenk (5) verbunden sind, wobei jedes Paddel (4) an seinen beiden Längsseiten durch mindestens entsprechende zwei Fadenmittel (6) an ein Trägermittel (7) angekoppelt ist, wobei die Paddel, das Gelenk (5) und die Fadenmittel (6) in der gleichen Ebene verlaufen und das dehnungsempfindliche Element bilden, wobei das System folgendes umfaßt:

- ein Mittel zum Beleuchten des Elements (3) mit einem Lichtstrahl mit modulierter Intensität zum Aktivieren des Elements (3), damit es bei seiner Resonanzfrequenz in einer entsprechenden Drehoszillations-Resonanzmode M_{nm} oszilliert,
- ein Mittel zum Bestimmen der Frequenzkennlinie der Einrichtung (3), wenn sie vorbestimmten Parameterbedingungen ausgesetzt ist,
- ein Mittel zum Aussetzen des Elements (3) den äußeren Parameterbedingungen und
- ein Mittel zum Erfassen des Lichtstrahls nach entsprechender Modifizierung durch das akti-

vierte Element (3),

dadurch gekennzeichnet, daß der Lichtstrahl einen Lichtstrahl mit mindestens frequenzmäßig durchlaufener modulierter Intensität bildet und daß das System weiterhin folgendes umfaßt:

- ein Mittel zur nachfolgenden Aktivierung von mindestens zwei Oszillations-Resonanzmoden,
- ein Mittel zum Messen der entsprechenden zwei Resonanzfrequenzen und
- Mittel zum entsprechenden Bestimmen zweier Parameterwerte durch Anpassen der Resonanzfrequenzen an die entsprechende Frequenzkennlinie.

Revendications

1. Méthode de contrôle des variations de contraintes d'un élément réagissant aux contraintes d'un dispositif de capteur au silicium micro-usiné, sous la forme d'un capteur papillon (3), qui comprend au moins deux ailettes rectangulaires (4) agencées en ligne et connectées l'une à l'autre au moyen d'une articulation (5) au niveau de leurs petits côtés en regard, chaque ailette (4) couplée, au niveau de ses deux grands côtés, à un moyen de support (7) au moyen d'au moins deux moyens d'attache (6) correspondants, les ailettes, l'articulation (5) et les moyens d'attache (6) se prolongeant dans le même plan et formant l'élément réagissant aux contraintes, la méthode comprenant les étapes:

   - d'irradiation dudit élément (3) par un faisceau de lumière avec une intensité modulée pour activer ledit élément (3) en vue d'osciller dans un mode d'oscillation de résonance de torsion correspondant M_{nm} à sa fréquence de résonance,
   - de détermination des courbes de réponse en fréquence dudit dispositif (3) lorsqu'il est soumis à des conditions de paramètres prédéfinis,
   - de soumission dudit élément (3) à des conditions de paramètres extérieurs, et
   - de détection du faisceau de lumière après qu'il a été modifié de manière correspondante par ledit élément activé (3),

   caractérisée en ce que ledit faisceau de lumière forme un faisceau de lumière avec au moins intensité modulée balayée en fréquence, et en ce que la méthode comprend en outre:

   - l'activation ultérieure d'au moins deux modes d'oscillation de résonance,
   - la mesure des deux fréquences de résonance correspondantes, et
   - la détermination de manière correspondante de deux valeurs de paramètres en ajustant les fréquences de résonance sur les courbes de réponse en fréquence correspondantes.

2. Méthode selon la revendication 1, dans laquelle les modes d'oscillation de résonance M_{02} et M_{04} sont activés.

3. Méthode selon la revendication 1, dans laquelle lesdits moyens d'attache (6) existent en une paire d'attaches en forme de V, dont les bases de V sont agencées sur lesdits côtés, et dont les extrémités de V sont agencées sur ledit moyen de support (7).

4. Méthode selon l'une quelconque des revendications précédentes, dans laquelle le dispositif est agencé à l'intérieur d'un logement tubulaire (2) où l'on a substantiellement fait le vide, qui est soumis auxdites conditions de paramètres extérieurs, transférées audit dispositif (3) par l'intermédiaire dudit moyen de support (7).

5. Méthode selon la revendication 4, dans laquelle ledit moyen de support (7) forme un moyen de console, agencé sur une paroi d'extrémité dudit logement (2) et connecté à celle-ci, la paroi d'extrémité fonctionnant comme une membrane pour lesdites conditions de paramètres extérieurs.

6. Méthode selon la revendication 4, dans laquelle ledit moyen de support (7) fait partie d'une construction de bras de levier (8), ladite construction (8) étant connectée à la paroi cylindrique dudit logement (2) pour transférer lesdites conditions de paramètres extérieurs.

7. Méthode selon la revendication 1, dans laquelle la fréquence est balayée entre 10 et 500 kHz, de préférence entre 50 et 200 kHz.

8. Méthode selon l'une quelconque des revendications 1 à 7, dans laquelle le faisceau de lumière irradiant le capteur papillon est focalisé en un point lumineux sur l'une desdites ailettes (4), la majeure partie du point lumineux étant localisée à côté de l'articulation (5).

9. Méthode selon l'une quelconque des revendications précédentes, dans laquelle le faisceau de lumière irradiant ledit élément (3) comprend en outre une composante de signal en ondes entretenues.

10. Méthode selon l'une quelconque des revendications précédentes, dans laquelle des valeurs de pression et de température sont déterminées.

11. Méthode selon l'une quelconque des revendica-

tions précédentes, dans laquelle des valeurs de pression et de température sont mesurées, respectivement entre 0 et 2000 bars et 0 et 350°C, de préférence entre 35 et 1000 bars et 20 et 200°C.

12. Système de contrôle des variations de contraintes d'un élément réagissant aux contraintes d'un dispositif de capteur au silicium micro-usiné, sous la forme d'un capteur papillon (3), qui comprend au moins deux ailettes rectangulaires (4) agencées en ligne et connectées l'une à l'autre au moyen d'une articulation (5) au niveau de leurs petits côtés en regard, chaque ailette (4) couplée, au niveau de ses deux grands côtés, à un moyen de support (7) au moyen d'au moins deux moyens d'attache (6) correspondants, les ailettes, l'articulation (5) et les moyens d'attache (6) se prolongeant dans le même plan et formant l'élément réagissant aux contraintes, le système comprenant:

- un moyen pour irradier ledit élément (3) par un faisceau de lumière avec une intensité modulée pour activer ledit élément (3) en vue d'osciller dans un mode d'oscillation de résonance de torsion correspondant M_{nm} à sa fréquence de résonance,
- un moyen pour déterminer des courbes de réponse en fréquence dudit dispositif (3) lorsqu'il est soumis à des conditions de paramètres prédéfinis,
- un moyen pour soumettre ledit élément (3) à des conditions de paramètres extérieurs, et
- un moyen pour détecter le faisceau de lumière après qu'il a été modifié de manière correspondante par ledit élément activé (3),

caractérisée en ce que ledit faisceau de lumière forme un faisceau de lumière avec au moins intensité modulée balayée en fréquence, et en ce que le système comprend en outre:

- un moyen pour activer ultérieurement au moins deux modes d'oscillation de résonance,
- un moyen pour mesurer les deux fréquences de résonance correspondantes, et
- un moyen pour déterminer de manière correspondante deux valeurs de paramètres en ajustant les fréquences de résonance sur les courbes de réponse en fréquence correspondantes.

FIG.1

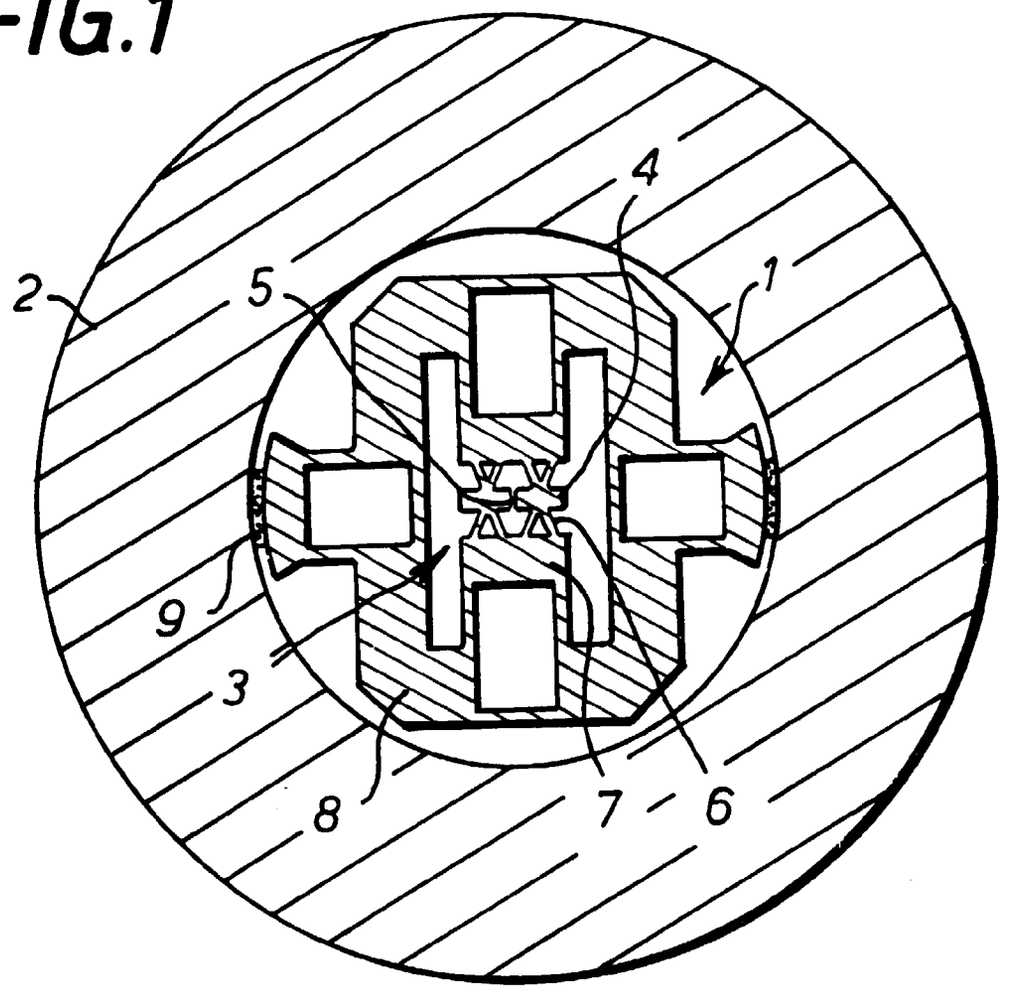


FIG.2

